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The Southeastern Minnesota Beacon Project for Community-driven Health Information Technology: Origins, Achievements, and Legacy

Christopher G. Chute
Mayo Clinic, chute@mayo.edu

Lacey A. Hart
Mayo Clinic, Hart.Lacey@mayo.edu

Alex K. Alexander
Mayo Clinic, Alexander.Alex@mayo.edu

Daniel W. Jensen
Olmsted County Public Health Services, jensen.dan@CO.OLMSTED.MN.US

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Background: The Office of the National Coordinator for Health Information Technology (ONC), as part of the American Recovery and Reinvestment Act of 2009 (ARRA) stimulus, established 17 projects throughout the United States targeting the introduction and meaningful use of health information technology (HIT). These 17 communities were intended to serve as an example of what could be accomplished. The SE Minnesota Beacon is one of these communities.

Methods: The community ultimately opted for peer-to-peer HIE, using Nationwide Health Information Network (NwHIN) Connect software. The clinical data repository was established using the infrastructure developed by the Regenstrief Institute, which operated as a trusted third party. As an extension to HIE, the consortium of county public health departments created a patient data portal for use by school nurses and parents. Childhood asthma was addressed by creating, exchanging, and maintaining an "asthma action plan" for each affected child, shared throughout the community, including through the patient portal. Diabetes management introduced patient treatment decision tools and patient quality of life measures, facilitating care. Influenza vaccination was enhanced by large-scale community reporting in partnership with the state vaccination registry. The methodology and principles for arriving at these solutions included community engagement, sustainability, scalability, standards, and best practices that fit a variety of organizations—from large, robust providers to small organizations.

Findings: The SE Minnesota Beacon demonstrated that all providers for a geographically defined population can cooperate in the development and shared governance of a low-cost, sustainable HIE, and the operation of a community-managed clinical data repository. Furthermore, these infrastructures can be leveraged to collaboratively improve the care of patients, as demonstrated for childhood asthma and adult diabetes mellitus.

Conclusion: The shared governance of HIT by a community can palpably change the scope and success of collaborations targeted to improve patient and community health care.

Disciplines
Community Health and Preventive Medicine | Health Information Technology | Health Services Research

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Conclusion: The shared governance of HIT by a community can palpably change the scope and success of collaborations targeted to improve patient and community health care.

Introduction

The Southeastern Minnesota (SE MN) Beacon, one of 17 funded by the Office of the National Coordinator for Health Information Technology (ONC) within the Department of Health and Human Services (HHS), was an experiment in promoting the adoption of health information technology (HIT) across a defined population area. We focused on the 11-county region in SE MN (Figure 1), including all traditional health care providers, all 11 county public health departments, and the nursing activities in all 47 school districts.

In the course of this effort, we succeeded in creating a comprehensive regional community with shared governance over peer-to-peer health information exchange (HIE) and a common clinical data repository. Two clinical applications of the communication infrastructure, together with three clinical process enhancements are described. The first application was the management of childhood asthma using shared, electronic "asthma action plans," while the second application was the integration of shared decision-making around treatment choice and patient-reported outcomes for quality

[i]Mayo Clinic, [ii]Olmsted County Public Health Services

Figure 1. The Geographic Footprint of the SE MN Beacon, with Partners and Participants
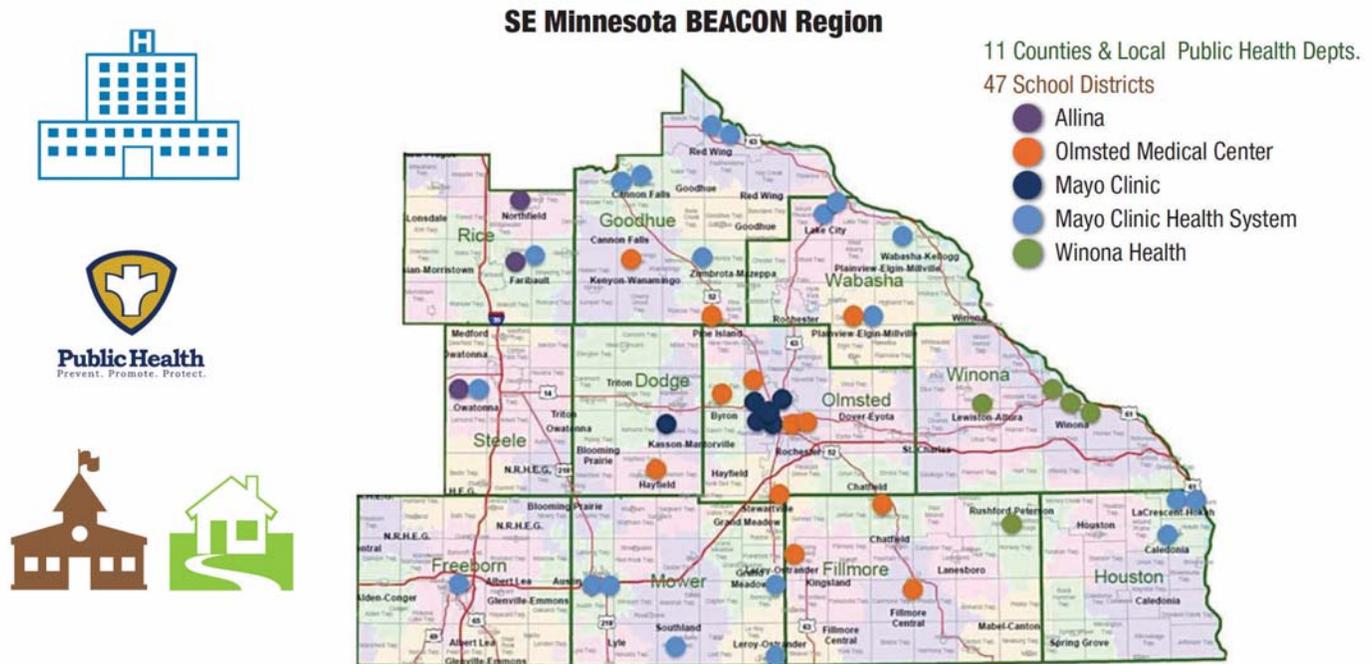
Note: All health care providers in the region participated.

of life applied to the management of adult diabetes. Cooperating with the Minnesota Department of Health and their collaboratively curated vaccination registry, we addressed the HIT infrastructure and processes for reporting of influenza vaccinations throughout the community. We also piloted two additional clinical process improvement programs in the direct use of shared health information, the first being care alerts followed by summaries exchanged between primary care providers and hospitals at time of care transfer, the second being the reconciliation of current medications between care providers and public health workers providing services to patients in their homes. This Beacon program sustains its achievements by the deliberate incorporation of activities and resources among the partners that originally formed the consortium.

Background

Health care has become profoundly information intensive, and the need for providers to exchange patient data and to coordinate care has become correspondingly important. The health care industry has lagged behind other industries, or even most American consumers, in the adoption of information technology and computing. To address this gap, as part of the American Recovery and Reinvestment Act of 2009 (ARRA), the federal government allocated $2 billion to the ONC to promote the adoption and "meaningful use"[1] of HIT. Among the programs initiated by ONC to address this mandate were the Beacon communities, which provided $250 million over three years to 17 communities[2-4] to demonstrate "how health IT investments and Meaningful Use of [EHRs] advance the vision of patient-centered care, while achieving the three-part aim of better health, better care at lower cost."[5]

Southeastern Minnesota has a half-century tradition of health services research and comparative effectiveness research involving cooperation and data sharing among regional providers. The Rochester Epidemiology Project (REP)[6,7] has been continuously funded by NIH for 50 years, coordinating a legacy of paper-record sharing for outcomes research and epidemiology; it has published over 2,000 peer-reviewed scholarly papers on disease incidence, prevalence, and natural history. Building on this tradition, a broader coalition in the SE MN region collaborated to create the SE MN Beacon,[8] eventually comprising all physician-based health care providers, public health departments, and school districts in the 11-county area (Figure 1). We were fortunate that all providers and counties were already using electronic health records (EHRs), and thus could focus on their connection and application to care improvement.

The community recognized the need to develop on-demand exchange of clinical data along with a complete repository of patient data to support clinical operations, research, public health surveillance, and community assessments. On the technical side, we opted to connect all members of the community through HIE. Recognizing that most patients' data will never be seen by an HIE where the information is exchanged only on request, we agreed to create a separate clinical data repository (CDR) of all patient data, secured so that contributors must agree to any queries across data sources. No identifiable data was exchanged through the CDR. Table 1 outlines the salient differences between HIE and CDR, as implemented in our Beacon.

Table 1. Contributions and Distinctions between HIE and CDR within the SE MN Beacon

	Health Information Exchange (HIE)	Clinical Data Repository (CDR)
Data Sources	Continuity of Care Document (CCD) Generated by provider electronic health records (EHR)	Dedicated, encrypted HL7 Data Feeds over Virtual Private Network (VPN)
Data Content	Patient summary data as specified by Meaningful Use phase 1 CCD	Demographics and identifiers Laboratory Medications Billing diagnoses and procedures Vital signs
Population Coverage	Only patients for whom an HIE request is made (<1% population)	Entire population (100%)
Use Cases	Clinical practice	Population metrics Public health Quality measures Approved research
Technology Base	NwHIN Connect protocol Mirth software appliances	Regenstrief Institute designed population database

On the implementation side, we initially focused on the community-based management of childhood asthma—engaging providers, school nurses, parents, and most importantly, the children. In parallel, we explored the management of shared patient decision-making tools and patient-reported outcomes for diabetes mellitus. We subsequently introduced flu vaccination promotion, and HIE around transitions of care and medication reconciliation.

Key Components of the Southeastern Minnesota (SE MN) Beacon Community
Health IT (HIT) Infrastructure and Governance
The SE MN Beacon included many members who had not previously been part of the REP, specifically Winona Health System, all 11 county public health departments, and all of the school districts. Together, these groups created an unincorporated community with the historical REP members: Mayo Clinic, Mayo Health System, and Olmsted Medical Center. At the time of Beacon's formation, there remained no independent physicians in the region.[9] Approximately halfway through the effort, the Allina Health System, which operates a 77-bed hospital in Owatonna in the western part of our 11-county area, joined the consortium and completed the comprehensive physician-based provider coverage of the region by our Beacon.

The community chartered a governance structure, which was with the approval of all members. The governance body involved a governing council with one representative from each entity. Voting was ceded to the major health care providers, and Olmsted County Public Health, which acted on behalf of all county public health departments and the school districts. This approach ensured everyone in the community had a voice and a place at the table, while no single entity had controlling interest over decisions.

The community consortium, by design and anticipating sustainability, did not at any time have any full-time employees dedicated to the SE MN Beacon. The direction, operation, and management of the SE MN Beacon were accomplished by members from partner organizations as part of their job requirements in their home institutions, although some salary was paid by the Beacon. This was a purposeful structure, defined so that at the end of the cooperative agreement funding from ONC, the community we had built would and did continue as part of the operations of the member organizations.

Health Information Exchange (HIE)
HIE is traditionally conducted in one of two ways, "hub and spoke" or peer-to-peer.[10] Hub and spoke conventionally creates a single directory and often a cached repository of patient data on behalf of providers within that specific HIE. Members typically pay an annual fee, and sometimes per-event charges for the centralized repository to service HIE requests between providers, often by generating the meaningful-use exchanged documents (such as the Clinical Care Document, CCD) from the central repository. The alternative peer-to-peer model obviates any central repository for HIE, instead relying on software utilities at each provider to service requests on demand directly from partners with whom it has established security and identity certification.

The SE MN Beacon initially anticipated using a Minnesota state-sponsored centralized HIE, and thus the hub-and-spoke approach. However, it quickly became apparent that the maintenance costs of this model would not be sustainable. We were fortunate in that Mayo Clinic by this time was among the founding members of the Connectivity Care Consortium, which also included Kaiser Permanente, Intermountain Healthcare, Geisinger Clinic, and Group Health of Puget Sound. That consortium was deploying peer-to-peer infrastructure based on the open-source NwHIN Connect[11] software sponsored by the ONC. Leveraging this experience and technology base in the form of Mirth[12] software appliances, the SE MN Beacon was able to deploy HIE throughout the SE MN region, including all 11 county public health nodes, for about 1 percent of the cost that would have been required for the more common hub-and-spoke implementations, with modest maintenance costs (Figure 2).

Community Clinical Data Repository
HIE services, even centralized hub-and-spoke models, rarely create a comprehensive repository of all patient information throughout a community; it is more efficient to collect and cache data on demand. A consequence of this strategy is that patients who have

Figure 2. Health Information Exchange (HIE) Network Based on Open-Source, Peer-to-Peer CONNECT[11] Software
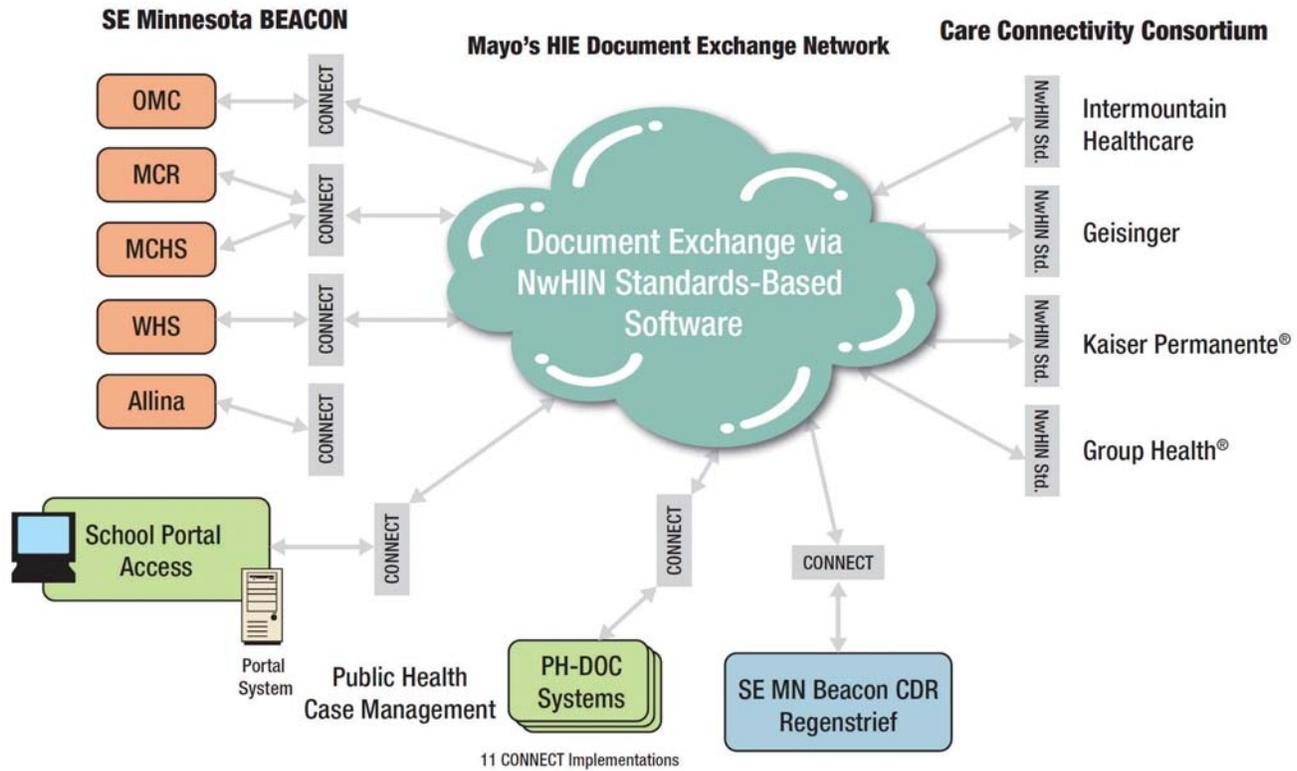
Note: *The right side corresponds to the national-scale Care Connectivity Consortium, with which the SE MN Beacon shared infrastructure; the left side and bottom show the SE MN Beacon HIE network.
Abbreviations: OMC = Olmsted Medical Center, MCR = Mayo Clinic Rochester, MCHS = Mayo Clinic Health System, WHS = Winona Health System, PH-Doc = Public Health Documentation (an EHR), CDR = Clinical Data Repository, NwHIN = Nationwide Health Information Network.

no HIE requests will be invisible to the HIE data store; we show in Table 1 that, for SE MN, that constitutes 99 percent of the population in the region. Furthermore, the SE MN Beacon aspired to the use of a CDR for outcomes research and comparative effectiveness research in the manner of the REP, but focusing on electronic data capture, integration, and query. Such a repository obviously has significantly different consenting and privacy issues associated with its use. Thus, in our original Beacon proposal, we anticipated a CDR operating in parallel with HIE, having significantly different operating conventions, data, and legal status (Table 1).

Our initial thought was to build a repository, informed by the examples of Informatics for Integrating Biology and the Bedside (i2b2)[13] repositories, but invoking the clinical data normalization tools emerging from the Mayo Clinic's Strategic Health IT Advanced Research Projects[14] award from ONC on secondary data use, SHARPn.[15,16] However, after discussions with colleagues at Regenstrief Institute, we explored leveraging their clinical data repository system, which had evolved over 40 years and was used as the basis for the Indiana HIE, rather than building our own from scratch. Each contributing entity from SE MN would have their data in a protected data partition, and thus could operate as a siloed data repository. The combination of affordability, scalability, partitioned security, and cross-query capability, managed by a trusted third party outside of the region provided by the Regenstrief Institute, were compelling and became our the basis for operating our CDR.

Participation in the eMERGE consortium,[17,18] where we contributed to the development of high-throughput clinical phenotyping algorithms,[19] had taught us that demographics, coded data (ICD and CPT administrative codes), laboratory values, and medication use would enable the identification of patient cohorts. Such cohort identification could form the numerators and denominators of quality metrics and could readily identify patients with antecedent conditions and clinical outcomes. Thus this information, together with Admission/Discharge/Transfer (ADT) data, comprised the core of CDR. The partners agreed that once we established live data connections between each of the SE MN and the Regenstrief data environment, additionally loading historical data for a three-year period before the beginning of the Beacon program would pose little incremental cost; this would allow the collection of six years of data throughout the region. Figure 3 outlines timelines for the HIE and CDR.

To preload and maintain data feeds into the CDR, each clinical partner and the consortium of county public health home health care providers (who shared a common EHR system), established HL7 V2 data feeds. These were interfaced, tested, and quality-controlled over several months. In some cases, these data were sent as CCDs, and were parsed by the Regenstrief data system into discreet data elements. Once established, these data connections were able to either continuously send clinical data from EHRs in near real time or batch them over a period of typically one day. Thus we had current data for every patient seen in the free-living

Figure 3. Timelines for Key Activities in the Development and Deployment of the SE MN Beacon Health Information Exchange (HIE) and the Clinical Data Repository

Key Activity	Sub Tasks	2011						2012												2013											
		J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Health Information Exchange	Architecture, Infrastructure, Team Building																														
	Testing and Connectivity																														
	CCD Generation																														
	Transition to Practice																														
	Pilot Go-Live																														
	Roll Out																														
	Outcome Measurement																														
	Sustainability and Post Beacon Plans																														
Clinical Data Repository	Testing, Connectivity																														
	Data Backload																														
	Production and Go-live																														
	Add Medication and Vitals																														
	Adding Allina Feeds																														
	Post Beacon Transition Plans																														

population residing within the 11-county area of SE MN. This data spanned a six-year period by the end of the Beacon phase of our effort.

Queries against the database were mediated by Regenstrief personnel as a trusted third party, who used their native query engine. All data was normalized into this historical Regenstrief data dictionary and elements, which are readily mappable to meaningful-use data standards, such as Logical Observation Identifiers Names and Codes (LOINC) and RxNorm.

Patient Portal

The Beacon community confronted a dilemma around the question of patient portals. Virtually all providers had a "tethered" patient portal associated with their EHRs. County public health organizations worked diligently to maintain strong connections between patients and their primary care providers, agnostic to physician provider organization. They were therefore opposed to interacting with a single, tethered patient portal that could undermine that relationship for provider organizations outside that single tethered system. Thus, picking one tethered portal would not generalize to the shared needs of the community. On the other hand, creating yet another portal for Beacon might confuse patients as to where they should go. Nevertheless, there was a shared desire to adopt a patient data portal that was viewed as a neutral party and without bestowing a competitive advantage to any provider within the region. Similarly, school systems had

not established a student-oriented health data portal, nor had they the financial resources to make such a portal a reality. Thus historically school sponsored portals were not an option, though this approach did raise any conflicts.

Our solution to address both issues was to develop a patient portal (Kids eHealth) shared by all county public health departments as an extension to HIE, which would be the primary conduit between the community providers and the school systems. To facilitate this, the counties, led by Olmsted County, significantly expanded the capabilities of their community-owned EHR system (PH-Doc) to receive Asthma Action Plans and associated metadata, complete quality review of incoming data, and transition the plans into the portal. The portal also supported closing the communication loop by facilitating school nurses returning messages to providers. The returning messages were structured to support the most common issues about which the providers wanted to be informed. The portal was also tied to the state immunization registry (MIIC) to provide access to student immunization data from within the portal. Feedback from the school nurses in the design phase led to a portal design where the school nurse selected the school at which that nurse was working and received a list of all action plans for that given school. This supported a population health perspective where the school nurse is empowered to develop responses based on data for the entire school.

Security, Privacy, and Consent

Security was achieved by 256-bit data encryption of data in transit at any point. In the case of HIE, this was accommodated by the NwHIN Connect software. For our CDR connections, either secure HTTP or FTP were the primary mechanisms. Encryption keys were manually delivered between agents by team members known to sending and receiving agents. The Regenstrief database has a long tradition of maintaining secure partitions within the Indiana HIE, which at the time hosted clinical data from over 6,000 providers in Indiana. Each contributing entity to the Regenstrief-hosted database was able to address queries across their own data, but not over the full set.

The Beacon governance body facilitated the joint development of data use agreements among the partners, permitting the merging of data from a single person seen at multiple sites (using Regenstrief master-patient-index or MPI software). Furthermore, this data use agreement permitted the execution of noncompetitive queries, such as community quality metrics or research questions, across the entire population base, when the governance body gave unanimous consent. Again, these queries were executed by Regenstrief personnel, who acted as a mutually trusted, neutral third party.

The state of Minnesota has legislation that has existed since 1996 requiring providers to obtain patient authorization for the use of their records for unspecified patient record research, such as epidemiological studies.[20] It is effectively a one-time opt-out system, though it can be revoked at any time. Each provider entity must independently obtain and maintain this authorization. Olmsted Medical Center and Mayo Clinic, partners in the REP, had well-established infrastructure for Minnesota Research Authorization (MRA); the other partners did not. Thus, a major effort of the Beacon community was the deployment and operation of MRA throughout all the communities. During the Beacon grant all 11 SE MN local public health agencies implemented MRA infrastructure as the first local public health agencies in the state to participate in this process. The average opt-out rate was less than 7 percent. State-mandated quality metrics and public health queries across the community did not filter results by MRA, however; all research queries honored this flag and results were removed from returned data sets by Regenstrief for all patients declining MRA. Unless explicitly authorized by IRBs, Regenstrief always returned de-identified datasets (invoking HIPAA safe harbor criteria) suitable for statistical analyses but not readily capable of further data linkage.

During the formative period of the Beacon effort, the operational team conducted several community focus groups, framed in the style of "deliberative democracy,"[21] to assess the communities' understanding of and attitudes toward HIE and CDR development. While concerns about privacy were consistently raised, they were satisfactorily addressed. On the whole, the community was strongly supportive of Beacon's efforts to improve care and population health.

Care Quality and Population Health

Asthma Management

Improving the management of asthma among school children with HIT was one of two core proposals in our Beacon application. Over several months we convened pediatricians, primary provider nurses, and school nurses to achieve consensus on the format and content of an "Asthma Action Plan" that would summarize the specific care needed in the event of an exacerbation for each child.[22] We achieved agreement on how to consent to the use and exchange of these plans among patients and parents. Technically, agreement could not be achieved on a single format for use in all EHRs by all providers; however, we did achieve consensus on the data elements, values, and related content of the plan. Furthermore, we were able to exchange the resulting plans as instances of CCDs using the HIE infrastructure. Pertinently, school nurses were able to view the most current action plans through the patient portal established by the county when consented by parents and patients.

Diabetes Care

Beacon complemented childhood asthma with adult diabetes mellitus as its second core clinical intervention. Two approaches were made in this effort. The first involved a series of shared decision-making tools, where physicians and patients together explored the risks and benefits of alternative treatment options for disease management. This was accomplished with graphical patient aids, which would visually illustrate the benefits of a specific therapy on disease outcomes and risks, using colored dots representing "populations" of patients with and without a specific therapy.[23] Beacon facilitated this effort by making these shared-decision-making tools electronically available throughout the Beacon community as open-source resources, mediated by the all-Beacon community fostered by the ONC.

The second intervention leveraged patient-reported outcomes of quality-of-life measures. These too were graphical in design, but depicted icons for domains of concern, such as relationships, health monitoring, emotional well-being, money, and similar topics.[24] Patients could then drill down into these social determinants of health domains and quickly report their associated feelings on an ordinal scale. Beacon also made these tools and resources electronically available as web forms throughout the community. The SE MN Beacon, in collaboration with the Mayo-based developers of these tools, made these resources available to our 16 partners in the national Beacon community, 4 of which incorporated these instruments in pilot studies.

Transitions of Care

Primary care providers, and especially public health workers who manage public health clients in their homes, may not realize that one of their patients has been admitted for an acute problem, nor be immediately aware of their discharge. To address this problem, Beacon piloted a program in Olmsted County Public Health where their client lists were prospectively consented for release of information, and linked to an application within Mayo Clinic's ADT system. Whenever one of their clients was admitted or

discharged, an alert was sent to the health department via NwHIN CONNECT Administrative Push,[25] and was documented in the PH-Doc patient chart. This alert appeared on the community health care worker's screen and was reinforced by an email and a text message, inviting them to log on to the patient portal and review the client's alert. While the alert carried basic information about what occurred, the public health worker could pull a CCD from the physician-provider portal to understand changes in health events or hospitalizations.

These communications about transitions of care facilitated appropriate discharge planning, post-acute-care follow-up; and timely, accurate information at the points of transfer could be coordinated. This pilot was expanded to all 11 SE MN local public health agencies and is actively being deployed to additional regional providers, thus expanding this successful pilot to the full Beacon footprint.

Medication Reconciliation with Public Health Providers
The PH-Doc system used by public health, as described above, acquired the ability to parse CCD and other HIE message packets into their component parts, including medications. Thus, public health workers were able, for consenting patients, to view the most up-to-date prescribed medication, on demand from primary care providers or posthospital discharge, and view a merged list of nonredundant medications. During home visits the public health nurse enters what medications the patient is actually taking. The system identifies medications taken or not taken by the patient, differing from a community consensus of prescribed medications, enabling a real-time conversation about differences from prescribed medications. These conversations can uncover issues not otherwise known to prescribing physicians. Having these understandings, the public health nurse is able to follow up with the provider, refer the patient for assistance (if it is a financial issue), and otherwise enhance prescribed medication compliance and safety.

This up-to-date, prescribed medication viewer obviates overmedication due to differing brand names or formulations, which might not be immediately apparent to the health care worker or the patient. Furthermore, the health care worker can compare this optimized list from community health care providers, in near-real time using a mobile device, with what is actually in the client's medicine cabinet. Thus, the combination of HIE, medication parsing and reconciliation, and home visits enabled vastly better medication compliance while in many cases also avoiding significant overmedication.

Innovations in Care Management
Telemedicine and Remote Monitoring
In our Beacon submission, we embedded a "deep" study of telemedicine and community connection within our 11-county footprint. Winona County and the Winona Health System had over the past decade won considerable acclaim for being recognized among the "most wired" health care communities in the nation.[26] While the SE MN Beacon could not afford to implement full-blown telemedicine to long-term care facilities, schools, senior centers, and other community resources, we could leverage and expand upon the investments—technical and cultural—that had been made in Winona. Furthermore, leveraging our HIE connections, the bilateral communication stream could be greatly focused through coherent telemedicine innovation. Thus, Winona County was our "deep dive" nested experiment in the marriage of HIE, HIT, and telemedicine.

Influenza Vaccination
Improvement in the completeness and reporting of vaccination rates has been a long-standing goal of public health. Given our close HIT connections with school systems, public health, and the provider community, we directed efforts to improve influenza vaccination rates and reporting. To improve rates, we organized public and district school nurses into schoolwide vaccination campaigns. Information, authorization and consent, and billing information were sent home with students. Uninsured students were covered by public health funds. Public health personnel rotated through school districts, partnering with school nurses.

To enhance influenza vaccination reporting, Beacon worked closely with the state vaccination registry and engaged "big box" providers of immunization (major drug store chains, department stores with "in-store" clinics, grocery stores, and other community providers) to report vaccinations. Previously, vaccinations outside of health care providers were substantially underreported. Cooperation with our outreach efforts was universal, and all non–health care vaccination centers subsequently submitted reports on all immunizations to the state registry with sufficient detail to support valid registry entries.

Findings
Implementation
Our core technologies, HIE and CDR, were deployed to all physician-based health providers and were operational by the end of our second year. We successfully addressed legal, cultural, privacy, and security concerns in these areas, which were substantial. These successes allowed for the follow-on implementation in the third year of our public health patient portal, transitions of care, asthma management, diabetes care enhancements, and public health medication reconciliation. We established, sustained, and expanded a cooperative governance structure that, while unincorporated, formed the basis for community communication, consensus, and collaboration.

Our most significant legacy is the engagement of public health workers and school nurses in close partnership with traditional health care–providing organizations in defining and achieving shared community goals to improve care. This is illustrated in our descriptions below of collaborative, community-driven care of students with asthma by school nurses and home-based medication reconciliation by public health care managers.

Effectiveness

HIE remains well integrated within the community as a peer-to-peer organization with modest maintenance costs. In some areas, such as between the Allina Hospital and the Owatonna Mayo Clinic facility, thousands of HIE events have occurred and continue to occur. The CDR was able to successfully generate state-mandated health quality indicators[27] computed at the level of the individual—regardless of where care was delivered. These patient-centric metrics, not surprisingly, significantly enhanced Minnesota health quality scores for all health providers by a few to tens of percentage points, as they were not penalized for required care that had already been delivered at another organization.

Transition of care was implemented late in the Beacon grant period, so quantitative evidence of improved outcomes is limited; however, case reports of "near-miss" medication events, particularly avoidance of overmedication, are strongly suggestive of measurable enhancement in overall care quality. In one incident a public health nurse had a high-risk prenatal visit scheduled, received an alert, pulled the CCD, and learned that the patient had miscarried. With this information, the nurse completed the visit as scheduled, providing referrals for grief counseling and support to the patient who had lost the child. The outcomes of this visit were significantly more effective as measured by appropriateness and compliance than if the nurse had made the prenatal home visit and not been prepared for this change in status.

The community efforts around coordination of asthma care, the formulation of shared asthma-action-plan data elements, and most importantly the enabling of school nurses to access up-to-date plans for children in their care, has transformed the organization of childhood asthma care in the community. Feedback from parents, school nurses, and providers has remained uniformly positive. The portal has 1,331 students; and 2,173 action plans; with 73 school nurse users across 23 public- and private-school districts (as of April 2014). The clinical impact from electronic access to asthma action plans since the piloting of these plans in 2009 in Olmsted County has resulted in a reduction of Emergency Department utilization among students in the school district from an annual baseline of 7 percent to a sustained rate under 2 percent.

Utilization metrics for diabetes patients overall were encouraging, even though many patients did not directly benefit from the electronic decision aids. During the Beacon period, diabetic patients hospitalized for long-term complications dropped from just under 3 percent to 1 percent, and 30-day readmission rates dropped from 1.2 percent to 0.4 percent.

School-based influenza vaccination rates were by far the most dramatic success of the Beacon. The number of student vaccinations administered by the school systems rose from a baseline of 174 in 2009 to 1,450 in 2012, a near order of magnitude improvement. Subjectively, school nurses and administration, public health, and parents expressed substantial enthusiasm and satisfaction for the program; this could not be uniformly said for the students although 80 percent of the flu vaccine was delivered nasally.

Sustainability

As mentioned at the beginning, the SE MN Beacon had no full-time personnel and was deliberately an unincorporated organization. However, by design it was structured to serve as a catalyst for community organizations to adopt new technology, methods, and resources and to incorporate them into their ordinary operations. Thus, when Beacon funding ended, the activities and initiatives did not. Most notably, HIE and its derivatives (transitions of care, public health portal, asthma care, and medication reconciliation) remain integrated into each community's operations, one year following the conclusion of the program

The CDR, managed by Regenstrief, was the one exception to this sustainability. Regenstrief was unable to sustain their honest broker and data repository role because they moved HIE operations from their academic organization to an affiliated commercial entity. The new commercial entity invoked a completely different data design and imposed a cost structure similar to traditional hub-and-spoke HIE systems. Thus community members are presently considering who they would designate as a new honest broker. Meanwhile, each organization holds the complete six-year cache of their CDR content in raw and normalized formats.

Discussion

The SE MN Beacon is a striking success of community members self-organizing into an unincorporated organization that is mutually committed to the common cause of improving health care throughout the community through the adoption of HIT. Our most significant contribution to the larger community is the practical and sustained demonstration that peer-to-peer HIE, at impressively low costs relative to many alternative models, can be readily implemented through the community. For example, each partner would have been expected to sustain annual assessments on the order of half a million dollars a year with a state-sponsored hub-and-spoke HIE, as compared with the a few thousand dollars per year in our current model. Furthermore, these HIE infrastructures have been successfully expanded into public health patient portals, school nurse data sharing services, and transition of care infrastructure.

The SE MN Beacon program was fortunate in having many characteristics that may make the generalizability of our success to other regions less reproducible. First, the area had 100 percent penetration of EHRs among all physician-based providers. Furthermore, all of these providers were clustered among a small and manageable number of organizations (Mayo Clinic, Mayo Clinic Health System, Olmsted Medical Center, Winona Health System, and Allina Health Care). All providers were committed to collaborative care, data sharing, and shared governance. Perhaps of equal importance is the remarkable sophistication and enthusiasm of the 11 county public health departments in our region, who were strong partners in the Beacon process.

Not everything we envisioned in our original Beacon proposal was achieved. We anticipated the ability to conduct population health management, i.e., the proactive monitoring of disease cohorts, such as the diabetes patients in a specific practice, against case management guidelines, across organizations. For example, if Olmsted Medical Center were following 1,500 diabetes patients and ensuring that they obtained the recommended HgA1C measurements on schedule, we proposed that with appropriate consent, that organization could query all records in the CDR for that patient to see if by chance the specified service had been delivered in another facility, and what that result or finding might be. Such fragmented care is common in communities that have primary and tertiary care providers in proximity. Regrettably, despite the successful implementation of the CDR, this vision had not been achieved at the completion of the project because of the late completion of the CDR within the funded project's life.

In conclusion, we demonstrated the successful deployment of HIT throughout a population base served by many providers and non-traditional health care organizations through the collaboration, cooperation, and shared governance of the processes. Furthermore, with few exceptions, these transformations persist beyond the ONC funding period as permanent changes to the partnering organizations, which are much more closely connected, informed, and engaged in achieving improved health care outcomes through coordinated care activities.

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